FLOOD PLAIN INFORMATION

GREAT FALLS, MONTANA
VOLUME II

MISSOURI RIVER

PREPARED FOR
CITY OF GREAT FALLS
COUNTY OF CASCADE STATE OF MONTANA
BY
DEPARTMENT OF THE ARMY, OMAHA DISTRICT, CORPS OF ENGINEERS, 68102
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BASIN MAP
NO SCALE

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PREFACE

This report, Volume II, of two volumes, describes the flood characteristics for the Missouri River reach extending from 3-1/2 miles upstream from Great Falls to Black Eagle Dam. Volume I, prepared in February 1973, identified the flood characteristics for the Sun River. The areas subject to flooding by the Missouri River include recreational, residential, industrial, and agricultural lands.

This report was prepared for the guidance of local officials in planning the use and regulation of the flood plain. In addition to accounts of past flooding at Great Falls, two potential floods are used to represent degrees of major flooding that may occur in the future. These two floods, Intermediate Regional and Standard Project Floods, are fully defined in the Glossary and should be given appropriate consideration in planning for safety of development in the flood plain. The two potential floods are shown by flooded area maps that delineate the approximate areas that would be inundated. Flood profiles show the water depths relative to the streambed and an elevation reference is given that can be applied across the width of the valley. Cross sections are presented to indicate ground level across the valley at specified locations and the overlying flood depths. The flood profiles and flooded area data presented are based on existing conditions of the basin, stream and valley when the report was prepared, and are reasonable, not precise, indications of probable occurrences. Possible future improvements to control floods are not a consideration of this report. The information in this report does not imply any Federal interest or authority to zone or regulate use of the flood plains; this is a local responsibility. The report provides a suitable basis for the adoption of land use controls to guide flood plain development, with consideration for environmental attributes, and thereby prevent intensification of loss problems. Since it identifies flood problems the report will stimulate the development of other flood damage reduction techniques such as flood control, removal of obstructions and flood proofing, which might be used in an overall Flood Plain Management (FPM) program.

This report was prepared by the Omaha District, Corps of Engineers, in accordance with the authority granted by Section 206 of the Flood Control Act of 1960 (Public Law 86-645) as amended. The study was requested by the Great Falls City-County Planning Board through the Montana Department of Natural Resources and Conservation.

The cooperation of the City-County Planning Board and other local officials in providing assistance and information was most helpful.

Distribution of the report to officials, agencies and individuals concerned with planning in the area covered is made by the Great Falls City-County Planning Board, Great Falls, Montana. The Corps of Engineers will provide interpretation and technical assistance, if requested, in application of the report data. Other guidelines available from the Corps of Engineers are a pamphlet, "Guidelines for Reducing Flood Damages" and a booklet, "Introduction to Flood Proofing".

BACKGROUND INFORMATION

SETTLEMENT

Backbreaking toil characterized Lewis and Clark's expedition of the Missouri River during the spring flood in the Great Falls area. On 13 June 1805 Lewis got his first glimpse of the falls, for which Great Falls is now named.[1]

It was 74 years later when Paris Gibson chanced to read an account of the Lewis and Clark expedition and conceived the idea of local industrial development based on power from the falls. Many settlers had come and gone in the intervening years but when Gibson and others explored the site in 1882 only one, Lucas Caranza, remained. The Gibson party obtained land rights and surveyed a townsite. Nearby coal beds were a further inducement to these pioneers. The year 1884 saw extensive building, 1885 the first newspaper, and a grand ball in March 1885 celebrated the completion of the first flour mill. The first railroad arrived in 1887 to serve a thriving community of 1,200. A silver-lead smelter began operation in 1888; in 1890 the local meat-packing industry was organized. Great Falls has further developed into a banking, commercial, and agricultural center.[2]

THE STREAM AND ITS VALLEY

The Missouri River basin, draining from south to north toward Great Falls drains about 21,183 square miles excluding the Sun River basin. Including the Sun River basin the drainage area is 23,100 square miles. The total drainage area at Morony Dam, about 11.0 miles northeast of Great Falls is 23,292 square miles. Average annual precipitation varies between 13 inches on the plains to over 30 inches in the high mountains. Elevations vary between 3300 feet, mean sea level (m.s.l.) and 9600 feet m.s.l. Temperatures in the basin range from 100°F in the summer to less than -50°F in the winter. The Missouri River drainage area upstream from

[1] Information from Lewis and Clark Journals

[2] From "Great Falls Yesterday" a Work Progress Administration Writer Project Supervised by Edith R. Maxwell.

Great Falls is considered by many as some of the most picturesque and scenic landscapes in the United States. The southeastern corner of the drainage includes a small portion of Yellowstone National Park in the State of Wyoming. The Big Hole, Beaverhead, Jefferson, Madison, and Gallatin Rivers make up the uppermost and primary tributaries of the Missouri in this area. Clark Canyon Dam, Lima Reservoir, Lower and Upper Red Rock Reservoirs provide control of the Beaverhead River while Hebgen Dam and Ennis Lake are located on the Madison River. Just upstream from Great Falls Hauser and Holter Dams, private power dams, and Canyon Ferry, a Bureau of Reclamation dam, are located on the Missouri River. Canyon Ferry is located about 133 river miles upstream from Great Falls and partially controls runoff from a drainage area of about 15,860 square miles. Within the study reach the Missouri River slope is about 1.1 feet per mile. A map of the Missouri River basin upstream from Great Falls is located facing the preface to this report.

DEVELOPMENT IN THE FLOOD PLAIN

The city of Great Falls is situated on the Missouri River at the confluence with the Sun River. The primary business section of Great Falls and a large part of the residential area lie east of the Missouri River at an elevation that precludes flood damage from occurring. That portion of the city which lies west of the Missouri, on either side of the Sun River is subject to flooding from both the Sun and Missouri Rivers. The Great Falls economy is based on manufacturing, trade, agriculture, lumber and tourism. Food, petroleum and coal, stone and clay, and metal goods are all products of the area. Much of the Missouri River flood plain in Great Falls is in agriculture with some portions in residential, commercial, and recreational uses. There are undeveloped areas on the Missouri River flood plain, in particular, to the south of Great Falls. The population of Great Falls grew from 31,697 in 1930 to 60,091 in 1970. In that 40-year span the compound rate of growth was equivalent to about 1.6 percent per year. The expanding population indicates continuing urbanization of rural

areas and unless future developments in the flood plain are controlled, additional flood damages in Great Falls could result. Figures 1, 2, 3, and 4 show the Missouri River channel and nearby development at the mouth of the Sun River and near Black Eagle Dam.

Figure 1. Missouri River, looking downstream - mouth of Sun River at left.

Figure 2. Missouri River, view downstream at Hwy 87.

Figure 3. Missouri River at Black Eagle Dam looking upstream.

Figure 4. Missouri River view downstream from Black Eagle Dam.

FLOOD SITUATION

SOURCES OF DATA AND RECORDS

The U. S. Geological Survey has, since 1957, maintained a water stage recorder 6 miles east of Ulm and 9 miles downstream from the mouth of Smith River. Records of Missouri River flow since 1953 at Morony Dam, 14 river miles downstream from Great Falls, are maintained by the Montana Power Company. Foxboro meters are used for determining the discharge through the power plant and a water-stage recorder on the reservoir determines the head on the tainter gates. The flows at the Ulm and Morony Dam gages are affected by irrigation, flood control, and power reservoirs located upstream from Great Falls. The USBR Canyon Ferry and Clark Canyon Dams, constructed March 1953, and August 1964 respectively, are multipurpose reservoirs which include flood control storage. Other flow records are kept at Hauser, Holter, Black Eagle, Rainbow, and Ryan Dams and Reservoirs along the Missouri River.

Most of the information on past floods was obtained from Corps of Engineers flood records. Flood accounts from the Great Falls Tribune and the Bozeman Daily Chronicle were a valuable aid in extending limited information. Photographs in this report are by Corps of Engineers personnel.

Detailed channel and valley cross sections, surveyed by the Corps of Engineers in 1965 and by the U. S. Geological Survey in 1973, were used to compute flood profiles. The flooded areas were plotted on 2-foot interval contour maps, available for a small area near the Sun River and on U. S. Geological Survey quadrangle maps for the remainder of the area. The flooded areas are shown on 1971 aerial photographs provided by the Montana Department of Highways.

FLOOD SEASON AND FLOOD CHARACTERISTICS

Major floods have occurred in the study reach of the Missouri River during the months of May and June. These months coincide with the periods of rainfall combined with heavy snowmelt in upstream areas resulting

in surface runoff in excess of soil infiltration amounts. Past floods may not be indicative of today's floods because of the control afforded by upstream reservoirs installed within the last 20 years. The June 1908 flood, the largest flood by the Missouri River ever to strike Great Falls was caused by unusually warm temperatures and higher than normal rainfall in May with torrential rainfall in early June adding to snowmelt water. All other large floods by the Missouri River at Great Falls have had the same general antecedent meteorologic and hydrologic conditions.

FACTORS AFFECTING FLOODING AND ITS IMPACT

Obstructions to flood flows - Five bridges cross the Missouri River and one power dam are located in the study reach. None of the bridges unduly restricts flood flows since the lowermost portion of the bridges is sufficiently high to pass large floods. Black Eagle Dam, located at the downstream limit of the study reach impedes the normal flow of water whenever all of the flashboards are extended causing a higher and flatter water surface upstream than when the flashboards are removed. Data in this report show flood conditions for all flashboards removed except for specifically noted profile data which show the condition if the flashboards were not removed. Floating debris can collect at bridges raising water levels upstream of the bridge. It is impossible to predict the degree or location of the accumulation of debris; therefore, for the purposes of this report, it was necessary to assume that there would be no accumulation of debris to clog any of the bridge openings. During floods, trees, brush and other vegetation growing in floodways impede flood flows, thus creating backwater and increased flood heights. The degree of overbank flow obstruction due to vegetation and buildings in the flood plain was considered in the hydraulic computations.

Flood damage reduction measures - After the large floods of 1953 and 1964 local people expressed a desire for flood control along the upper reaches of the Missouri River. The Bureau of Reclamation and the Corps of Engineers then allocated flood control storage in the Canyon Ferry Reservoir in February 1966. The Bureau of Reclamation Clark Canyon Dam,

constructed in August 1964, also provides for flood control on the Beaverhead River, in the extreme upper limits of the Missouri River drainage area. The Omaha District, Corps of Engineers has recommended a plan calling for levees on both banks of the Missouri River, both upstream and downstream from the Sun River mouth. The project has not been constructed because of difficulties in providing local sponsorship.

Other factors and their impacts - A portion of the Sun River flood plain is common with the Missouri River flood plain. Adequate preliminary flood warning at Great Falls is not a particular problem; slow response by residents of the flood plain to warnings of potential flooding could add to flood damages.

Flood warning and forecasting - The National Oceanic and Atmospheric Administration, National Weather Service provides flash flood alerts whenever radar, located at Missoula, Montana, indicates heavy runoff producing rains are occurring. The Weather Service Office in Great Falls provides weather forecasts at least twice daily with special forecasts of severe storms in addition to flood warnings and snowmelt advisories to local news media and officials.

Flood fighting and emergency evacuation plans - During the 1964 flood at Great Falls, local officials, police and firemen, military personnel, and many volunteers worked magnificiently to protect human life and to reduce flood damages in the Sun River flood plain. The local Civil Defense office, as a part of total City-County emergency planning, has since developed warning and evacuation procedures to be used during future floods. Emergency flood action is in two phases, (1) property evacuation and (2) total evacuation of people from the flood plain, with the latter phase to commence 6 hours prior to the estimated flood crest arrival at Great Falls. Plans include established emergency traffic patterns and control, recording of people moving in and out of flood prone areas, provision for temporary

shelters and property storage facilities, and for standby emergency vehicles such as boats and military helicopters for surveillance and rescue.

Material storage on the flood plain - Often floatable material stored on the flood plain is washed away during flooding to collect at points downstream and impede flood flows. The Missouri River flood plain is relatively clean of such material and any debris problem is expected to be primarily from natural sources.

PAST FLOODS

SUMMARY OF HISTORICAL FLOODS

Notable floods on the Missouri River in the study reach occurred in 1908, 1916, 1948, 1953 and 1964. Although complete records are not available for earlier floods, the 1964 flood inflicted the greatest damage to Great Falls, with a peak discharge of 76,000 cubic feet per second on 10 June 1964. The above flood dates also coincide with Sun River flood periods in Great Falls.

FLOOD RECORDS

Annual peak flows for the Missouri River near Great Falls are available from the U.S. Geological Survey records. Records since July 1953 are available from the Morony Dam Station, 11.0 miles northeast of Great Falls with a drainage area of 23,292 square miles. The maximum discharge at Morony Dam occurred on 10 June 1964 with the discharge equal to 72,000 cubic feet per second. Additional flow measurement stations are maintained upstream from Great Falls at Holter Dam where records date back to 1945 and downstream from Great Falls at Black Eagle, and Fort Benton where records date back to 1890.

Local newspapers and Corps of Engineers flood reports contain narrative accounts of past floods. Table 1 shows flood peak discharges of the Missouri River at Great Falls and is indicative of peak flows in the study reach. Flows are partially regulated by reservoirs located upstream from Great Falls.

TABLE I

HISTORIC FLOOD PEAK DISCHARGES

MISSOURI RIVER NEAR GREAT FALLS

Date, Year	Maximum Discharge C.F.S. Black Eagle	Morony Dam
7 June 1908	120,000	-
June 1916	57,400	-
6 June 1948	51,500	
4 June 1953	62,000	-
10 June 1964	76,000*	72,000*

*Majority of flow from Sun River

FLOOD DESCRIPTIONS

May and June 1908 - Snowmelt and heavy rains in May and June contributed to the highest recorded peak discharge on the Missouri River at Great Falls. A large plaque mounted in the east stone abutment of the Great Northern Railroad underpass at Sixth Street North shows the elevation of the 7 June 1908 flood at Great Falls, at 3316.19 feet, mean sea level.

Great Falls Tribune (Reconstruction of 1908 flood event of 1968):

"On June 8, the rains slackened and the city was isolated. Railroads were out in every direction, as were telephone and telegraph service. The smelter closed, affecting approximately 5,000 men. Headgates were completely destroyed. The general office, which was abandoned, was spared flooding.

"The water in the channels around Park Island was flowing at a rate of about four and one-half m.p.h. It was flowing over the present golf course at a rate of about three m.p.h. into the Sun as far west as the Sixth Street bridge. At this point it was diverted toward the Great Northern shops by the Sun which also was high, and cutting across country from the brewery to the shops.

"Looking up the Sun Valley from Prospect Hill it appeared a lake as far as one could see. Montana Power records of 1908 show a peak flow of 120,000 cubic feet per second at Black Eagle. Their records show a peak of 62,000 in 1953 and a peak of 76,000 in 1964. This is the combined flow of the Sun and the Missouri. Both rivers affect the flooding of the Country Club addition. The 1953 flood was more disastrous to this addition with 14,000 c.f.s. less water than the 1964 flood. The 1953 flood was a Missouri caper and 1964 one of the Sun.

"The excitement of seeing buildings and hay stacks surge against the Great Northern railroad bridge was described by many. The buildings would break up and pass under and the stacks would pass under mostly intact. The water was 15 feet deep and had a velocity of 5.2 m.p.h. full depth. Therefore anything being stopped at the surface would roll under. There was no major problem with debris at this bridge.

"The dozen or so homes built on the east bank of Broadwater Bay between the pumping plant and the railroad bridge were flooded but not washed away. Brush along the riverbank protected them from the direct current."

A photograph of a part of Great Falls during the flood is reproduced as figure 5.

4 through 19 June 1948 - Rapid snowmelt runoff, resulting from a precipitous temperature rise beginning on 1 June 1948, and additional runoff from a general rainfall occurring from 3 through 11 June over the entire Missouri River drainage basin, caused the Missouri River to overflow its banks from 1 through 19 June 1948. River Drive in Great Falls

Montana, was flooded and closed to traffic in two locations, from 3 through 19 June. The first location was at the Great Northern R.R. underpass one-fourth mile south of Central Avenue bridge and the second at the Central Avenue bridge over the Missouri River. In the vicinity of Great Falls the Giant Springs access road 4 miles northeast was inundated for a distance of about 1200 feet, isolating the State Fish Hatchery. The water works road south of Great Falls serving a well settled residential area was flooded in numerous places and closed to traffic from 3 through 19 June. Initial flooding from 4 to 9 June was caused by overbank flow of the Sun River while later flooding resulted from backwater from the Missouri River. About 65 residences were damaged by first floor flooding. About 23 homes were flooded by the Missouri, fifteen of which had flooding over the first floor. Damages for this flood were estimated at $74,000.

<u>Bozeman Daily Chronicle</u>

> "The Missouri and its tributaries were falling slowly after a rampage which flooded much lowland and forced evacuation of about 65 families in the Great Falls area. The Missouri flow near Great Falls dropped from 51,000 cubic feet per second to 49,000 cubic feet per second and officials said the season's peak probably had been reached. The Sun River, which enters the Missouri at Great Falls, was still out of its banks but receding ----."

Photographs of the June 1948 flood on the Missouri River at Great Falls are reproduced as figures 6 through 9.

May and June 1953 - Prolonged rainfall over the basin upstream from Great Falls in May caused flooding between 3 and 10 June 1953. Flooding from the Missouri took place in the portion of Great Falls located adjacent to the water works road in the southern portion of the city. Eighteen residences, 15 of which sustained basement and first floor flooding, were flooded. Seven families were forced to vacate their homes for periods of

from one to three weeks. Total urban damages due to this flood were estimated at $47,860.

7 through 13 June 1964 - Northwestern Montana experienced its worst natural disaster during the period 7 through 13 June 1964. Heavy rainfall on 7 and 8 June centered near the Continental Divide and with high snowmelt runoff caused unprecedented flooding in the Sun, Marias, and upper Missouri River basins. Flood damage in the western part of Great Falls from both the Sun River and the Missouri River was estimated at approximately $4,400,000. About 3,000 persons were evacuated from the flooded areas and about 681 homes and 24 businesses sustained damages. Depths of from 10 to 12 feet were noted on several homes located in low-lying areas.

Figure 5. 7 June 1903, John Largent building, water at floor level. 1916 flood was 8 inches higher.

Figure 6. 6 June 1948, view looking west from east bank of Missouri River near Sun River mouth. Flooding of golf course and garden plots.

Figure 7. 7 June 1948, view looking west from east bank of Missouri River. Flooding of Great Falls Boat Club buildings.

Figure 8. 7 June 1948, view of flooding of county road and park area near waterworks plant.

Figure 9. 5 June 1948, aerial view of east bank Missouri River, 4 miles upstream from Great Falls. Note flooded farm buildings.

Figure 10. Potential flood depths, at east end of Meadowlark Drive.

Figure 11. Potential flood depths, on right bank, at city water intake.

Figure 12. Potential flood depths at Great Northern Underpass. Level hand indicates the high water elevation of the 1908 flood.

Figure 13. Potential flood depths, on left bank, at Meadowlark Country Club tennis courts.

FUTURE FLOODS

Floods of the same or larger magnitude as those that have occurred in the past could occur in the future. Larger floods have been experienced in the past on streams with similar geographical and physiographical characteristics as those found in the study area. Similar combinations of rainfall and runoff which caused these floods could occur in the study area. Therefore, to determine the flooding potential of the study area, it was necessary to consider storms and floods that have occurred in regions of like topography, watershed cover, and physical characteristics. The estimates of the Intermediate Regional Flood and the Standard Project Flood as presented in this report are based on the existing development of the watershed.

INTERMEDIATE REGIONAL FLOOD

The Intermediate Regional Flood is defined as one that occurs once in 100 years on the average, although it could occur in any year. The peak flow of this flood was developed from statistical analyses of streamflow records at Ulm, Montana and at Morony Dam. Within the study reach the Intermediate Regional Flood discharge on the Missouri River at Great Falls is 49,000 c.f.s. upstream from the mouth of the Sun River and 71,000 c.f.s. downstream from the Sun River mouth.

STANDARD PROJECT FLOOD

The Standard Project Flood is defined as a major flood that can be expected to occur from a severe combination of meteorological and hydrological conditions that is considered reasonably characteristic of the geographical area in which the study area is located, excluding extremely rare combinations. The Corps of Engineers, in cooperation with the NOAA Weather Service, has made comprehensive studies and investigations based on the past records of experienced storms and floods and has developed generalized procedures for estimating the flood potential of streams.

The Standard Project Flood is presented in this report as the practical upper limit of flooding. Storms that would produce this flood are uncommon, and it is difficult to assign frequencies of occurrence with any reasonable degree of accuracy. The Standard Project Flood discharge on the Missouri River at Great Falls would be 100,000 c.f.s. upstream from the Sun River and 120,000 c.f.s. downstream from the Sun River.

FREQUENCY

Floods larger than the Standard Project Flood could occur. The 1908 flood was larger than the Intermediate Regional Flood and about equal to the Standard Project Flood. However, floods smaller than either the Intermediate Regional Flood or the Standard Project Flood are much more common, with an average peak annual discharge of about 21,300 c.f.s. for the past 17 years at Morony Dam. The Standard Project Flood is not the largest flood that can occur in the study reach, but the probability of larger floods becomes increasingly remote.

HAZARDS OF LARGE FLOODS

The extent of damage caused by any flood depends on the topography of the area flooded, depth and duration of flooding, velocity of flow, rate of rise, and developments in the flood plain. An Intermediate Regional or Standard Project Flood on the Missouri River would result in the inundation of residential, commercial, and industrial properties in the study area. Deep floodwater flowing at high velocity and carrying floating debris would create conditions hazardous to persons and vehicles attempting to cross flooded areas. In general, floodwater two or more feet deep and flowing at a velocity of 3 or more feet per second could easily sweep an adult person off his feet, thus creating definite danger of injury or drowning. Rapidly rising and swiftly flowing floodwater may trap persons in homes that are ultimately destroyed, or in vehicles that are ultimately submerged or floated. Water lines can be ruptured by deposits of debris and the force of floodwaters, thus creating the possibility of contaminated domestic water supplies. Damaged sanitary sewer

lines and sewage treatment plants could result in the pollution of floodwaters creating health hazards. Isolation of areas by floodwater could create hazards in terms of medical, fire, or law enforcement emergencies.

Flooded areas and flood damages - The areas along the study reach of the Missouri River that would be flooded by the Intermediate Regional Flood and the Standard Project Flood are shown on plates 3 through 5. Water surface profiles for these floods were determined using backwater computations employing the Standard Step Method. The profiles on plate 6 show the depth of flooding in the channel and the elevation of the water surfaces over the adjacent flood plain. Plate 7 portrays cross sections across the flood plain and shows ground elevation and depths of overbank flooding. Reference points coinciding with the location of cross sections are provided to locate flood elevations at intervals along the river. The reference points are located on both the "Flooded Area" plates and the "Profile" plates. Table 2, page 29, lists reference point data including elevations of the streambed and the Intermediate Regional and Standard Project Floods. Depths of flow for the Intermediate Regional and Standard Project Floods can be estimated from the profiles, cross sections, or reference table. Where accuracy is needed to delineate flooded area, the appropriate flood elevation can be taken from one of these sources and compared to a surveyed ground point elevation in the flood plain. Two sets of profile data are shown portraying the conditions of the flashboards at Black Eagle Dam. The most likely condition with the flashboards removed is shown by the colored profile symbols. The extreme condition would be if the flashboards were not removed. South of Great Falls in the study reach agricultural land and residences would be flooded by large floods. Farm homes and out-buildings in addition to county roads could be inundated. Included in the potential flood area south of the city are residential areas on the east bank. Near the mouth of the Sun River the west bank potential flood area includes the Meadowlark golf course and a residential area west of the golf course. Downstream from the mouth of the Sun River, very little area is flooded. Only a few industrial buildings and utilities would be subject to flooding

on both the left and right banks, with the exception of a residential area subject to flooding located on the left bank just downstream from the Sun River mouth. Some of the structures shown in the flood plain may, due to locally higher ground, be above potential flood elevations. For a specific situation where accuracy of flooded area is required, the appropriate flood elevation can be found from the profiles, the cross sections, or the reference table and that elevation located by survey on the flood plain will establish the flood limits.

Obstructions - During floods, debris collecting on bridges could decrease their carrying capacity and cause greater water depths (backwater effect) upstream of these structures. Since the occurrence and amount of debris are indeterminate factors, only the physical characteristics of the structures were considered in preparing profiles of the Intermediate Regional and Standard Project Floods. Similarly, the maps of flooded areas show the backwater effect of obstructive bridges, but do not reflect increased water surface elevation that could be caused by debris collecting against the structures, or by deposition of silt in the stream channel under structures. The five bridges over the Missouri in Great Falls do not materially obstruct flood flows. The water surface profiles show the effect of the structures on the water surface. Raised roadways as well as buildings on the flood plain will also tend to obstruct flows.

Velocities of flow - Fast moving floodwaters create hazards during potential floods at Great Falls. Velocities of three feet per second with depths of two feet or more are considered dangerous. Overbank flow velocities at the upstream and downstream limits of the study area during an Intermediate Regional Flood occurrence would average about 0.5 feet per second while near the mouth of the Sun River the velocity would be about 1.5 feet per second. Overbank flow velocities during a Standard Project Flood occurrence would be about 1.0 feet per second at both upstream and downstream limits of the study area and about 2.5 feet per

second near the Sun River. Channel velocities for both the Intermediate Regional Flood and the Standard Project Flood would average about 5.1 feet per second and 7.8 feet per second, respectively. Velocities in localized areas can be much higher than the average velocities cited above and all flooding areas should be considered hazardous.

Rate of rise and duration of flooding - The rate of rise, or peaking time, of future large floods on the Missouri River at Great Falls is about 2-1/2 days. Flood duration is about 9 days.

GLOSSARY

Backwater

The resulting high water surface in a given stream due to a downstream obstruction or high stages in an intersecting stream.

Flood

An overflow on lands not normally covered by water and that are used or usable by man. Floods have two essential characteristics: The inundation of land is temporary; and the land is adjacent to and inundated by overflow from a river or stream or an ocean, lake or other body of standing water.

Normally a flood is considered as any temporary rise in streamflow or stage, but not the ponding of surface water, that results in significant adverse effects in the vicinity. Adverse effects may include damages from overflow of land areas, temporary backwater effects in sewers and local drainage channels, creation of unsanitary conditions or other unfavorable situations by deposition of materials in stream channels during flood recessions, use of ground water coincident with increased streamflow, and other problems.

Flood Crest

The maximum stage or elevation reached by the waters of a flood at a given location.

Flood Plain

The relatively flat area or lowlands adjoining the channel of a river, stream or water course or ocean, lake or other body of standing water, which has been or may be covered by flood water.

Flood Profile

A graph showing the relationship of water surface elevation to location, the latter generally expressed as distance above mouth for a stream of water flowing in an open channel. It is generally drawn to show surface elevation for the crest of a specific flood, but may be prepared for conditions at a given time or stage.

Flood Stage

The stage or elevation at which overflow of the natural banks of a stream or body of water begins in the reach or area in which the elevation is measured.

Head Loss

The effect of obstructions, such as narrow bridge openings or buildings that limit the area through which water must flow, raising the surface of the water upstream from the obstruction.

Intermediate Regional Flood

A flood having a one percent probability of occurrence in any year or an average frequency of occurrence in the order of once in 100 years. The flood may occur in any year. It is based on statistical analysis of streamflow records and analyses of rainfall and runoff characteristics in the general region of the watershed.

Left Bank

The bank on the left side of a river, stream or water course, looking downstream.

Reference Point

A numbered point identifying a specific location for correlating the data shown in various forms throughout the report.

Right Bank

The bank on the right side of a river, stream or water course, looking downstream.

Standard Project Flood

The flood that may be expected from the most severe combination of meteorological and hydrological conditions that are considered reasonably characteristic of the geographical area in which the drainage basin is located, excluding extremely rare combinations. Peak discharges for these floods are generally about 40 percent to 60 percent of the Probable Maximum Floods for the same basins. Such floods, as used by the Corps of Engineers, are intended as practicable expressions of the degree of protection that should be sought in the design of flood control works, the failure of which might be disastrous.

Top of Waterway

This is the roof of the opening in a stream crossing through which water flows under normal conditions. It is the underside of the deck span - sometimes called "low steel", the roof of a box culvert or the crown of an arched or circular culvert.

TABLE 2

FLOOD PLAIN REFERENCE DATA

MISSOURI RIVER, GREAT FALLS, MONTANA

Identification	Reference Point Number	Distance in Feet From Dam	Stream Bed Elevation Ft. M.S.L.	Intermediate Regional Flood Elevation Ft. M.S.L.		Standard Project Flood Elevation Ft. M.S.L.		Bearing
				A	B	A	B	
Upstream Limit of study	1	45,720	3299.9	3322.0	3322.6	3327.4	3328.2	N 55°E
	2	43,800	3302.5	3321.7	3322.3	3326.6	3327.5	N 61°E
	3	40,900	3300.0	3321.4	3322.0	3326.4	3327.3	N 88°E
Cross Section 1-1	4	38,925	3296.7	3320.9	3321.6	3325.6	3326.7	N 84°E
	5	35,400	3302.5	3320.6	3321.4	3325.5	3326.6	N 58°E
	6	30,450	3297.6	3320.0	3320.9	3324.9	3326.2	N 77°E
	7	26,080	3304.6	3319.7	3320.6	3324.1	3325.5	N 89°W
	8	24,940	3300.0	3319.6	3320.6	3324.0	3325.5	N 88°E
	9	24,250	3297.0	3319.6	3320.6	3324.0	3325.5	N 85°E
Cross Section 2-2	10	22,750	3298.0	3319.4	3320.5	3323.7	3325.3	N 88°E
	11	22,350	3298.2	3319.4	3320.4	3323.7	3325.2	N 89°W
	12	20,850	3292.8	3319.3	3320.3	3323.5	3325.1	N 50°W
Highway 89 Bypass	13	20,170	3299.1	U/S 3319.2	3320.2	3323.1	3324.8	
				D/S 3319.1	3320.2	3323.0	3324.7	
	14	19,320	3298.4	3318.6	3319.8	3322.4	3324.2	N 73°W

TABLE 2

FLOOD PLAIN REFERENCE DATA

MISSOURI RIVER, GREAT FALLS, MONTANA

Identification	Reference Point Number	Distance in Feet From Dam	Stream Bed Elevation Ft. M.S.L.		Intermediate Regional Flood Elevation Ft. M.S.L.		Standard Project Flood Elevation Ft. M.S.L.		Bearing
					A	B	A	B	
Great Northern RR	15	16,440	3306.5	U/S	3317.3	3318.9	3320.7	3323.2	
				D/S	3317.1	3318.8	3320.4	3323.1	
	16	15,600	3306.7		3316.6	3318.5	3320.0	3323.0	N 86°W
U.S. Highway 89 and 1st Avenue	17	14,600	3302.4	U/S	3316.3	3318.4	3319.6	3322.7	
				D/S	3316.2	3318.3	3319.5	3322.7	
	18	12,380	3298.4		3311.9	3317.5	3316.1	3321.9	N 66°W
	19	10,140	3298.0		3311.6	3317.5	3315.9	3321.9	N 38°W
Cross Section 3-3	20	7,450	3290.6		3310.2	3317.1	3314.3	3321.3	N 18°W
State Highway 87	21	4,900	3297.0		3308.7	3316.9	3312.8	3321.0	N 1°W
	22	3,360	3295.7		3307.8	3316.8	3312.0	3320.8	N 17°E
	23	500	3290.5		3306.0	3316.5	3309.9	3320.4	N 21°W
Black Eagle Dam	24	0	-		3305.5	3316.5	3309.3	3320.3	

Downstream Limit of study

A = Assumed all flashboard planks removed at Black Eagle Dam

B = Assumed no flashboard planks removed at Black Eagle Dam

U/S Upstream side of bridge

D/S Downstream side of bridge

MISSOURI RIVER BASIN
GREAT FALLS, MONTANA

MISSOURI RIVER
PLATE INDEX MAP

U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1974

NO SCALE

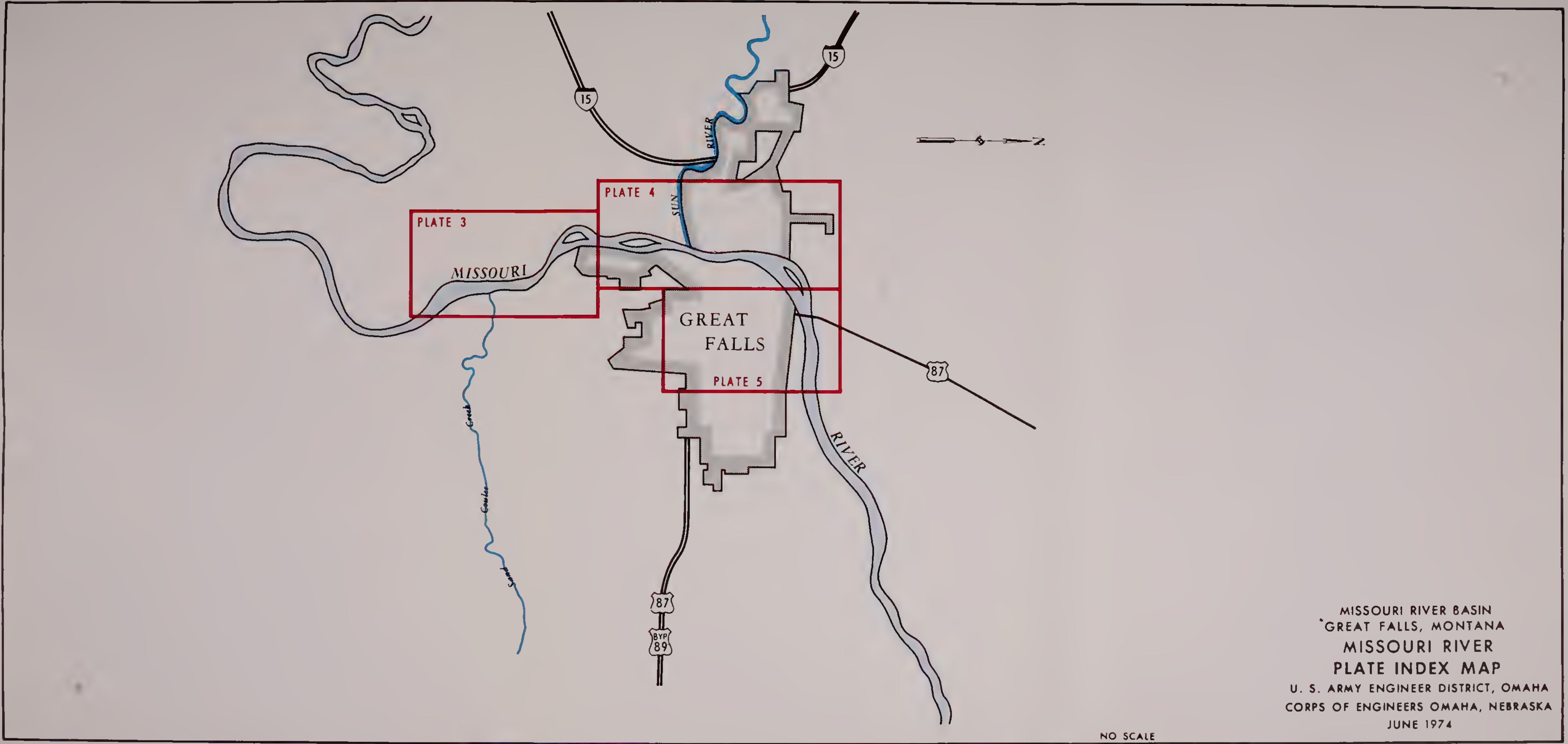

15
15
SUN RIVER
PLATE 4
PLATE 3
MISSOURI
RIVER
GREAT FALLS
PLATE 5
87
87
BYP 89
Sand Coulee Creek
N
MISSOURI RIVER BASIN
GREAT FALLS, MONTANA
MISSOURI RIVER
PLATE INDEX MAP
U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1974
NO SCALE

PLATE 2

LEGEND:

INTERMEDIATE REGIONAL FLOOD

STANDARD PROJECT FLOOD

Channel and Valley Cross Section

Reference Point - Also locations of surveyed cross sections

NOTES:

1. For the location of this plate see Plate Index Map (Plate 2).
2. For Illustrated Cross Sections, see Plate 7.
3. For Profile, see Plate 6.
4. For flood elevations at the reference points, see Table 2.

SCALE IN FEET

1000 0 1000 2000

MISSOURI RIVER BASIN
GREAT FALLS, MONTANA

MISSOURI RIVER

FLOODED AREAS

U. S ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1974

MISSOURI RIVER BASIN
GREAT FALLS, MONTANA
MISSOURI RIVER
FLOODED AREAS
U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1974
SCALE IN FEET
1000 0 1000 2000
FOR NOTES AND LEGEND SEE PLATES 3 & 5.
MEADOWLARK SCHOOL
MEADOWLARK COUNTRY CLUB
SUN RIVER
GREAT NORTHERN RR
C M St P & P RR
FAIRGROUND
MISSOURI
RIVER
FLOW
RIVER DRIVE
G-N-RR
GREAT NORTHERN RR
MATCH LINE PLATE 3
MATCH LINE PLATE 5
GREAT FALLS
10TH AVE SOUTH
5TH AVE SOUTH
1ST AVE NORTH
5TH STREET NORTH
RIVERSIDE PARK
SQUAW ISLAND
SEWAGE DISPOSAL

LEGEND:

INTERMEDIATE REGIONAL FLOOD
STANDARD PROJECT FLOOD

3 Channel and Valley Cross Section

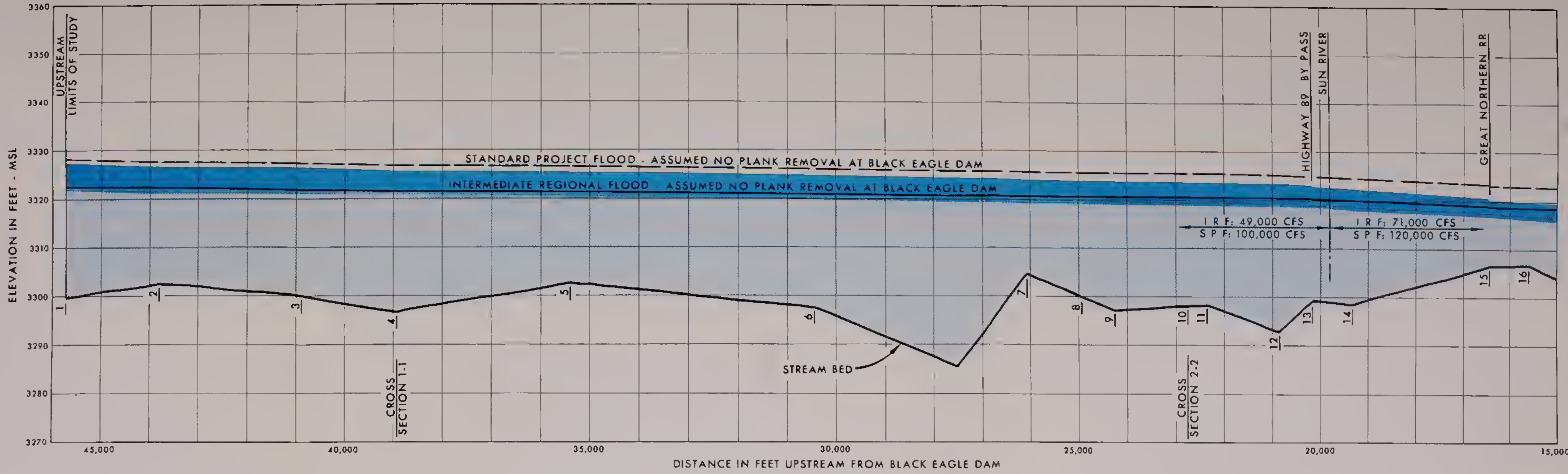
2 Reference Point - Also locations of surveyed cross sections

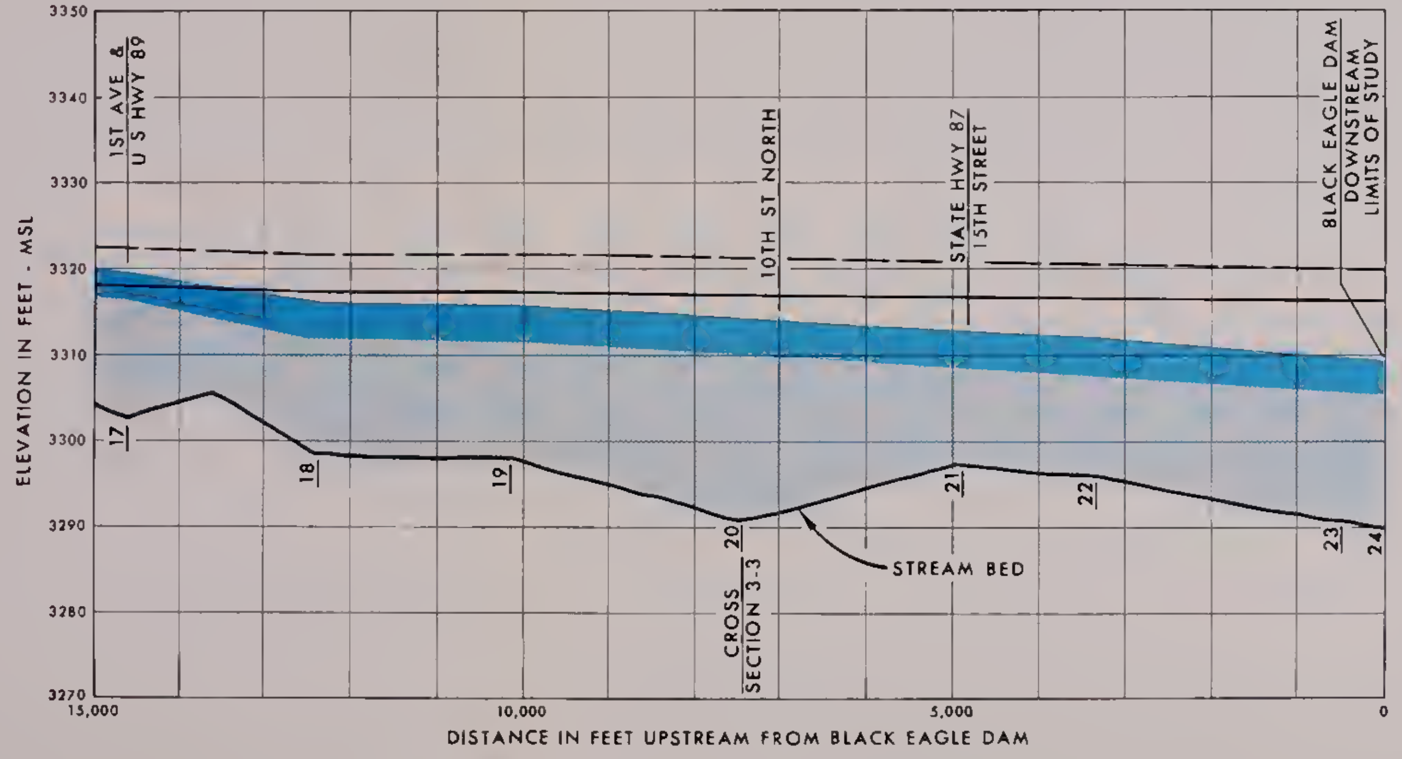
NOTES:

1. For the location of this plate see Plate Index Map (Plate 2).
2. For Illustrated Cross Sections, see Plate 7.
3. For Profile, see Plate 6.
4. For flood elevations at the reference points, see Table 2.

SCALE IN FEET
1000 0 1000 2000

MISSOURI RIVER BASIN
GREAT FALLS, MONTANA
MISSOURI RIVER
FLOODED AREAS
U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1974





LEGEND:

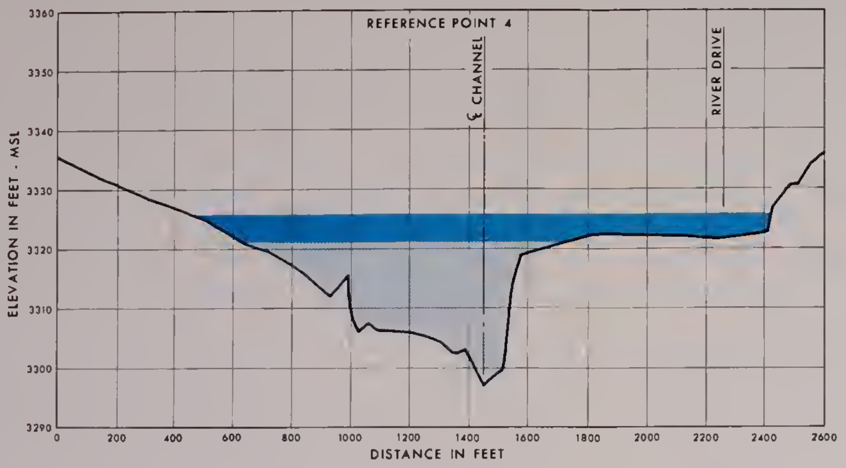
INTERMEDIATE REGIONAL FLOOD } STANDARD PROJECT FLOOD

PLANKS REMOVED AT BLACK EAGLE DAM

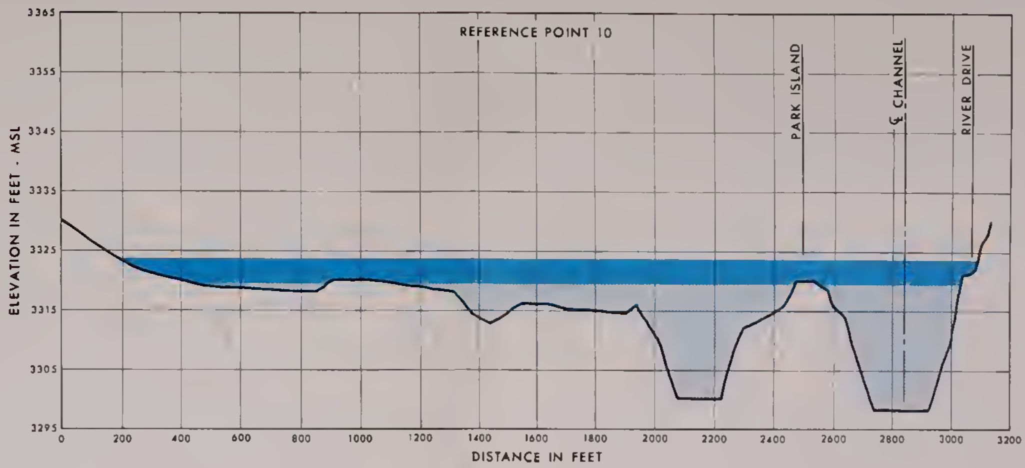
NOTES:

1. For location of Cross Sections, see Plates 3, 4, & 5.
2. For Illustrated Cross Sections, see Plate 7.
3. For flood elevations at the reference points, see Table 2.

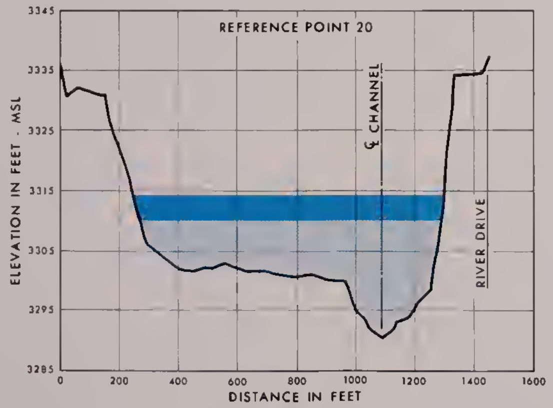
MISSOURI RIVER BASIN
GREAT FALLS, MONTANA
MISSOURI RIVER
PROFILE
U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1974



CROSS SECTION 1-1



CROSS SECTION 2-2



CROSS SECTION 3-3

LEGEND:

NOTES

1. For location of Cross Sections, see Plates 3, 4, & 5.

MISSOURI RIVER BASIN
GREAT FALLS, MONTANA

MISSOURI RIVER

CROSS SECTIONS

U. S. ARMY ENGINEER DISTRICT, OMAHA
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JUNE 1974